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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
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EXAMINER	
COLEMAN, WILLIAM D	

ART UNIT	PAPER NUMBER
2823	

DATE MAILED: 06/10/2004

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No.	Applicant(s)	
	09/484,303	AHN ET AL.	
	Examiner	Art Unit	
	W. David Coleman	2823	

-- Th MAILING DATE of this communication app ars on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *17 February 2004*.

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *5-13,36-41 and 43-64* is/are pending in the application.

4a) Of the above claim(s) *36-41* is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *5-13 and 43-64* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08) Paper No(s)/Mail Date *2/04*.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: _____.

DETAILED ACTION

Claim Rejections - 35 USC § 102

1. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

A person shall be entitled to a patent unless-

(e) the invention was described in (1) an application for patent, published under section 122(b), by another filed in the United States before the invention by the applicant for patent or (2) a patent granted on an application for patent by another filed in the United States before the invention by the applicant for patent, except that an international application filed under the treaty defined in section 351(a) shall have the effects for purposes of this subsection of an application filed in the United States only if the international application designated the United States and was published under Article 21(2) of such treaty in the English language.

2. Claims 5-6, 43, 47, 54, 57, 60, 61, 62, 63 and 64 are rejected under 35 U.S.C. 102(e) as being anticipated by Mikagi (6,153,507).

3. Mikagi teaches a method comprising:

forming a conductive structure; Fig.6a, el. 107a over a substrate 101, with the conductive structure having a surface (interface) confronting the substrate;

forming a diffusion-barrier lining around the conductive structure after forming the conductive structure; fig.6c, e1.108a with at least a portion of the diffusion barrier lining contacting the surface of the conductive structure (as seen in FIGS. 7A-7F),

forming an insulative structure around the conductive structure after forming the diffusion-barrier lining; fig.6d, e1.110a; and

wherein forming the conductive structures comprises applying a copper-, silver-, or gold-based material; col.7, In.54.

Mikagi also teaches forming a first conductive structure with contact plugs that contact an integrated circuit substrate, and wired portions that intersect at least some of the contact plugs; fig.3, e1.107a, wherein the diffusion barrier lining has a thickness in a range of two to ten nanometers over substantially all of the exposed portions of the conductive structure; col.9, In.36, and wherein the insulative structure is formed by depositing a material that includes silicon oxide in the spaces; fig.4b, e1.108e, col.3, In.1-5.

Mikagi also teaches a method comprising:

forming a conductive structure over a substrate, with the conductive structure having a first surface spaced from and in a confronting relationship with the substrate; and

forming a diffusion barrier after forming the conductive structure, with at least a first portion of the diffusion barrier between the surface of the conductive structure and the substrate (please see FIGS. 71-7F).

Mikagi also teaches the method of claim 60, wherein the first portion of the diffusion barrier contacts the surface of the conductive structure.

Mikagi also teaches the method of claim 61, wherein the conductive structure has a second surface opposing the first surface, and the diffusion barrier has a second portion overlying the second surface (please note that FIG. 4C discloses this limitation).

Mikagi also teaches the method of claim 62, wherein the second portion of the diffusion barrier layer contacts the second surface of the conductive structure.

Mikagi also teaches the method of claim 60, further comprising an insulative structure after forming the diffusion barrier, with the diffusion barrier having a portion between the first portion of the diffusion barrier and the substrate.

Claim Rejections - 35 USC § 103

4. The following is a quotation of 35 U.S.C. 103(x) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains.
Patentability shall not be negatived by the manner in which the invention was made.

5. Claim 8 is rejected under 35 U.S.C. 103(a) as being unpatentable over Mikagi as applied to claims 5-6, 43, 47, 54, and 57 above, and further in view of Jin et al. (Materials Research Society; 1997).

6. Mikagi appears not to specifically disclose forming the insulative structure comprises spin-coating an aerogel or xerogel. Jin teaches i forming the insulative structure comprises spin-coating an aerogel or xerogel; p.465, par.2. It would have been obvious to one of ordinary skill in the art at the time of the invention to use the spin-coating method and materials of Jin with the structure formed by Mikagi, so as to form an insulative layer that has the properties of low moisture absorption, high dielectric strength, low stress, and good gap fill capability, see abstract of Jin.

7. Claims 9, 12-13 are rejected under 35 U.S.C. 103(a) as being unpatentable over Mikagi as applied to claims 5-6, 43, 47. 54, and 57 above, and further in view of Beinglass et al. (5,940,733). Mikagi appears not to specifically state, wherein forming

the diffusion-barrier lining comprises forming a graded composition of WSi, where x varies from 2.0 to 2.5; nor wherein forming the diffusion-barrier lining comprises: introducing tungsten hexaflouride and hydrogen gases into a wafer processing chamber for a predetermined amount of time; nor introducing silane gas into the chamber a first predetermined time after introducing the tungsten hexaflouride gas; nor terminating introduction of the silane gas a second predetermined time before terminating introduction of the tungsten hexaflouride and hydrogen gases into the chamber; nor wherein the first and second times are in the range of about one to about three seconds. Beinglass teaches wherein forming the diffusion-barrier lining comprises forming a graded composition of WSi, where x varies from 2.0 to 2.5; col.4, In.51-56, and wherein forming the diffusion-barrier lining comprises: introducing tungsten hexaflouride and hydrogen gases into a wafer processing chamber for a predetermined amount of time; and introducing silane gas into the chamber a first predetermined time; col.4, In.33-50.

It would have been obvious to one of ordinary skill in the art at the time of the invention to combine Beinglass with Mikagi to form a graded diffusion barrier having reduced Silicon concentrations at the interfaces, so as to create more of a metal - metal interface, thus increasing the adhesion at the Cu-W interface and reducing the resistance of the interface and thus lowering the total resistance of the interconnect. Further, reduced silicon at the barrier/insulator interface would increase silicon diffusion from the insulator layer, thus increasing the bonding strength of the insulator to the barrier layer; col.1, In.62 thru col.2, In.14. Silicon gettering also would provide diffusion traps in the insulator region creating a better diffusion barrier.

It would have been obvious to one of ordinary skill in the art at the time of the invention to introduce silane gas into the chamber a first predetermined time after introducing the tungsten

hexaflouride gas and terminating introduction of the silane gas a second predetermined time before terminating introduction of the tungsten hexaflouride and hydrogen gases into the chamber; and wherein the first and second times are in the range of about one to about three seconds, to decrease the silicon concentration at both interfaces of the barrier layer in order to increase adhesion, conductivity, and barrier effectiveness. The time delays of the first and second times are an optimization problem, well within the skill level of an ordinary artisan. Further, it is well known in the art that dopant concentrations can be reduced by merely shutting off the dopant source, and thus it would be obvious to shut off the silicon dopant source at those times in the barrier growth process at the times that the barrier layer interface layers are being formed. One would expect that such interface regions would amount to a few seconds of the deposition process.

8. Claims 10, 11, 48-53, 55-56, and 58-59 are rejected under 35 U.S.C. 103(a) as being unpatentable over Mikagi and Beinglass as applied to claims 5, 6, 9, 12-13, 43, 47, 54, and 57 above, and further in view of Hirata et al. (NTT System Electronics Laboratories).

9. Mikagi and Beinglass appear not to disclose nitriding the graded composition of WSix; nor wherein nitriding the graded composition of WSi, comprises exciting a plasma with argon gas. Hirata teaches nitriding a tungsten silicide layer, see

introduction. It would have been obvious to one of ordinary skill in the art at the time of the invention to combine the teachings of Hirata with Mikagi and Beinglass to nitride the graded tungsten silicide barrier layer to further increase the barrier layer's capability to prevent the diffusion of Cu; see Hirata, section 2, par.3. Hirata teaches the Cu does not react with N, thus

nitrogen stuffing the barrier layer is very beneficial to the teachings of Mikagi and Beinglass, and would be combined.

Further, It would have been obvious to one of ordinary skill in the art at the time of the invention to facilitate the use of the nitrogen stuffing process of Hirata with a carrier gas containing argon gas, col.4, In.33-50, and exciting a plasma to order to increase the energy of the nitrogen atoms, to increase their reactivity, thus facilitating the ability of stuffing nitrogen into the barrier layer, thus improving the barrier layer's ability to stop the diffusion of copper.

10. Claims 44 and 45 are rejected under 35 U.S.C. 103(a) as being unpatentable over Mikagi as applied to claims 5-6, 43, 47, 54, and 57 above, and further in view of Zhao et al. (5,674,787).

11. Mikagi teaches wherein forming the first conductive structure comprises: forming a mask layer on the substrate with contact plug holes that open to the integrated circuit substrate, and trenches intersecting at least some of the contact plug holes; fig.3, e1.104c, removing excess material to form the wired portions; fig.7b and 7c, el. 107a, and forming a second conductive structure on top of the first conductive structure before removing the portion of the mask layer; fig.3d, e1.105c, and removing at least a portion of the mask layer to form the spaces between the portions of the first conductive structure, fig.3b, e1.104c, 107x. Note that in the process of removing portions of layers 107 and 106, to form the first conductive structure, inherently the etch process will remove some of the masking layer, thus forming spaces.

12. Mikagi does not appear to teach depositing a seed layer over the mask layer; nor electroplating conductive material over the seed layer to form the contact plugs. Zhao teaches

depositing a seed layer over the mask layer; fig.4, el.21, and electroless deposition of conductive material over the seed layer to form the contact plugs, fig.5, el.23, col.5, In.47-49. It would be obvious to one of ordinary skill in the art at the time of the invention to combine the teaching of Zhao with Mikagi to use a seed layer to assist in the electroplating or electroless deposition of copper, which are selective deposition processes, which affords those skilled in the art to avoid difficulties in etching Cu or the utilization of CMP methods, col.1, In.55 to col.2, In.6. Further, It would be obvious to one of ordinary skill in the art at the time of the invention to use the well-known electroplating process as a substitute selective deposition process to the electroless process, so as to increase the speed of the deposition, thus increasing throughput.

13. Claim 46 is rejected under 35 U.S.C. 103(x) as being unpatentable over Mikagi and Zhao as applied to claims 5-6, 43-45, 47, 54, and 57 above, and further in view of Abraham (6,004,884).

14. Mikagi and Zhao appear not to specifically teach forming an adhesion layer over the mask layer before electroplating. Abraham teaches forming an adhesion layer over the mask layer before electroplating, col.5, In.30-39. It would be obvious to one of ordinary skill in the art at the time of the invention to combine Abraham with Mikagi and Zhao to use an adhesion layer to insure that the conductive structure remain on the mask layer and thus decrease the manufacturing failure rate of the device.

Conclusion

15. Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

16. A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

17. Any inquiry concerning this communication or earlier communications from the examiner should be directed to W. David Coleman whose telephone number is 571-272-1856. The examiner can normally be reached on 9:00 AM-5:00 PM.

18. If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Olik Chaudhuri can be reached on 571-272-1855. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

19. Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

W. DAVID COLEMAN
PRIMARY EXAMINER